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F16F 7/12

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F2S SCM

(56) Documents Cited
GB 2305487 A **GB 2083162 A** **GB 2003254 A**
GB 1588328 A **GB 1582606 A** **WO 95/25646 A1**

(58) Field of Search
UK CL (Edition P) **F2S SCM**
INT CL^6 **F16F 7/12**
Online: WPI, EDOC, JAPIO

(54) Abstract Title
Impact energy absorber

(57) An impact energy absorber 30 comprises a plasically deformable body which is generally cuboid and of honeycomb section constructed from individual corrugated sheets. The body includes at least one void in the form of apertures 32. The diameters of the apertures decrease from one end to the other to produce a controlled incremental collapse.

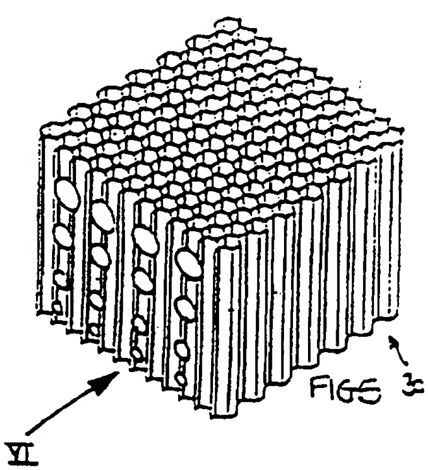

FIG5

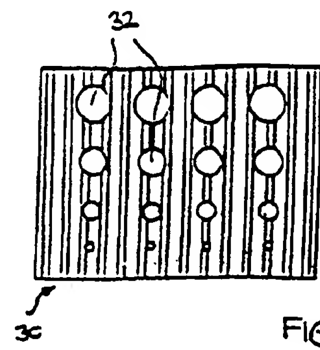

FIG6

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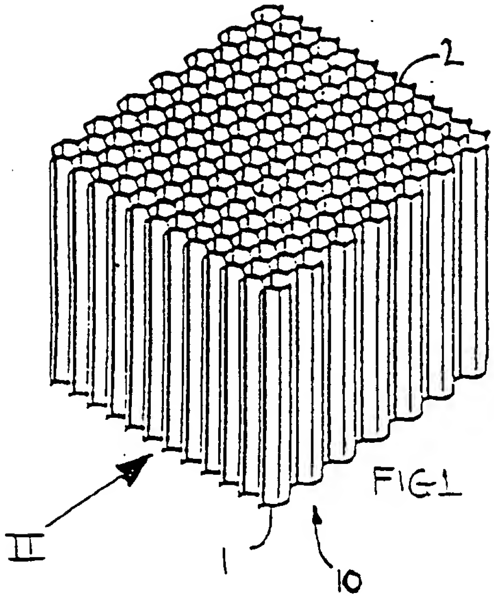


FIG1

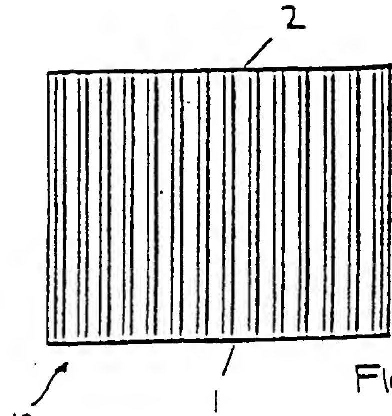


FIG2

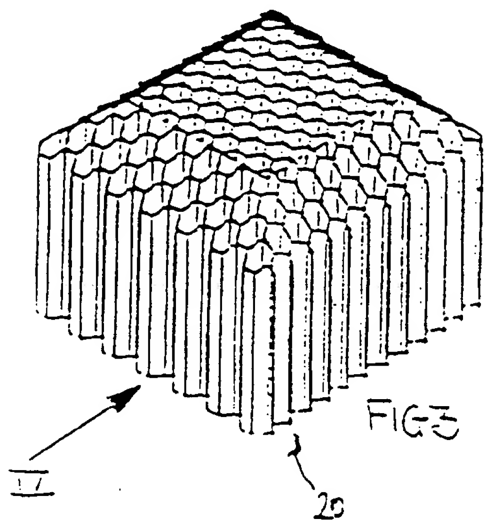


FIG3

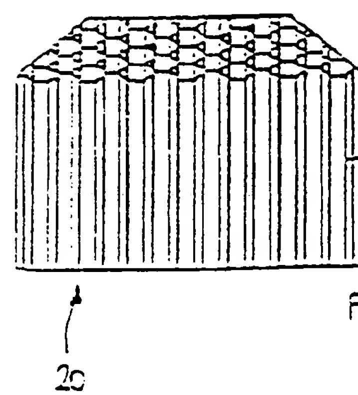


FIG4

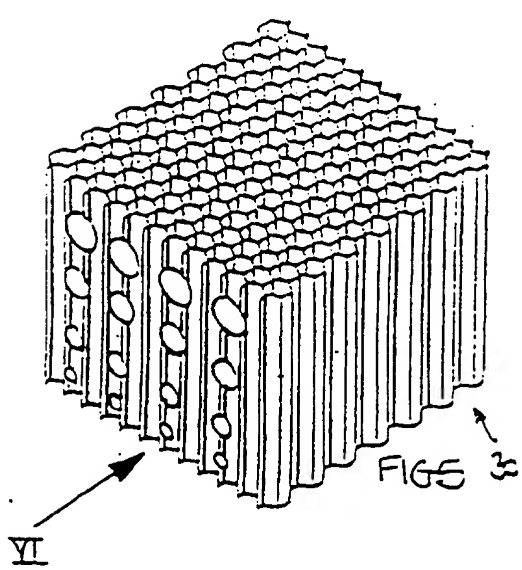


FIG5

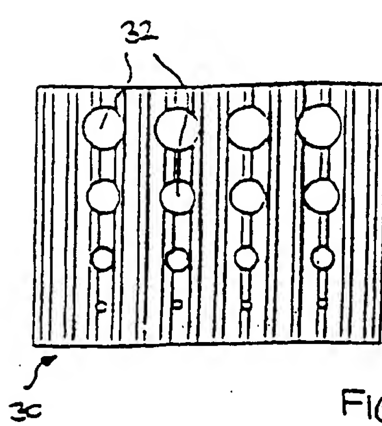


FIG6

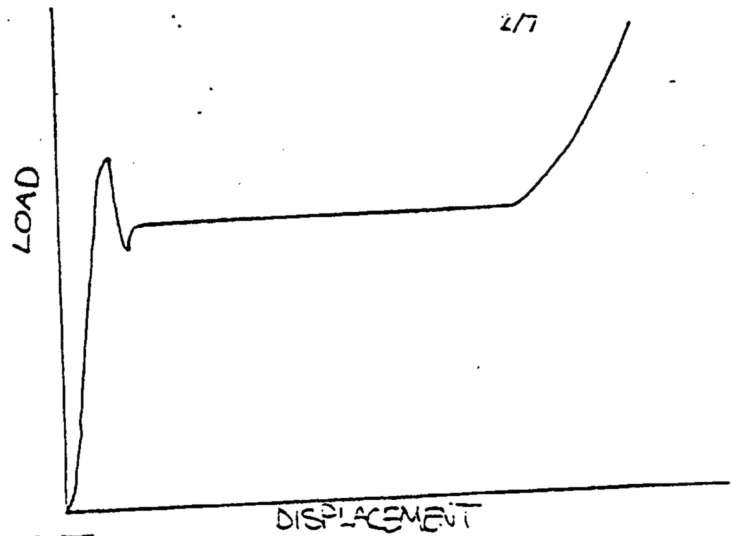


FIG 7

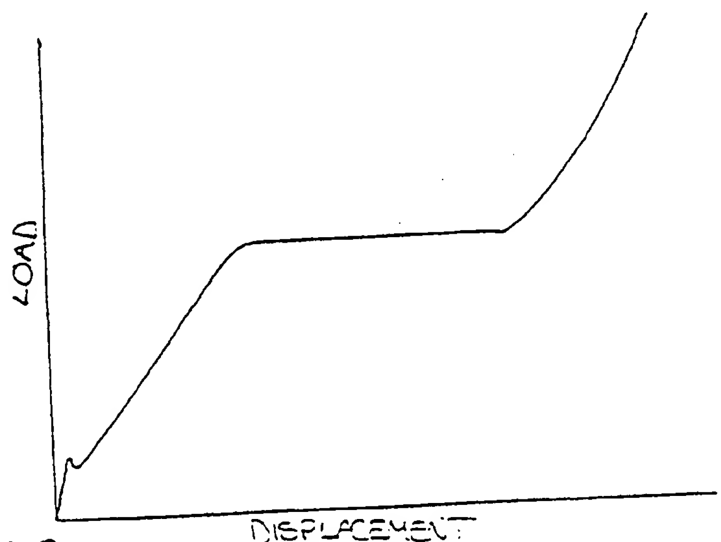


FIG 8

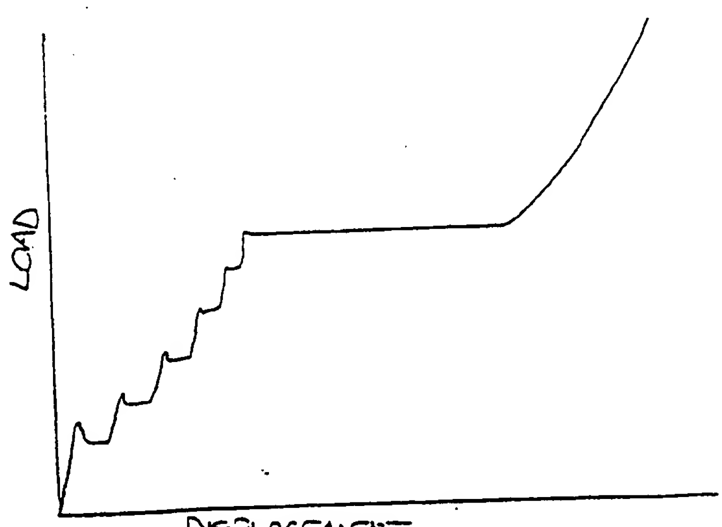
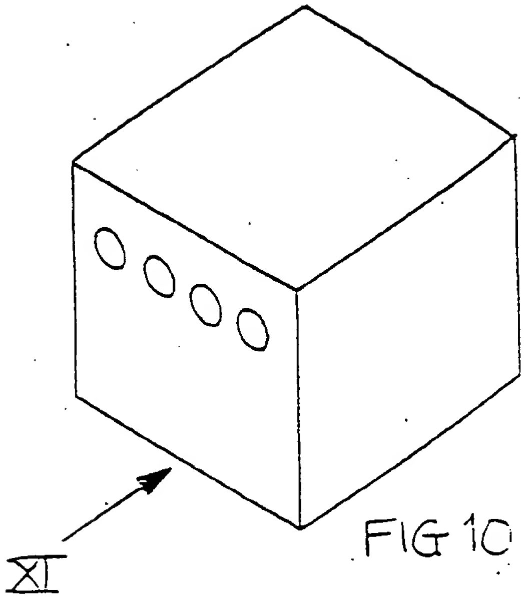


FIG 9



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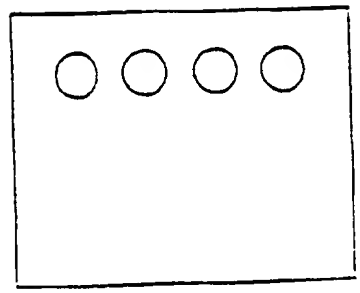

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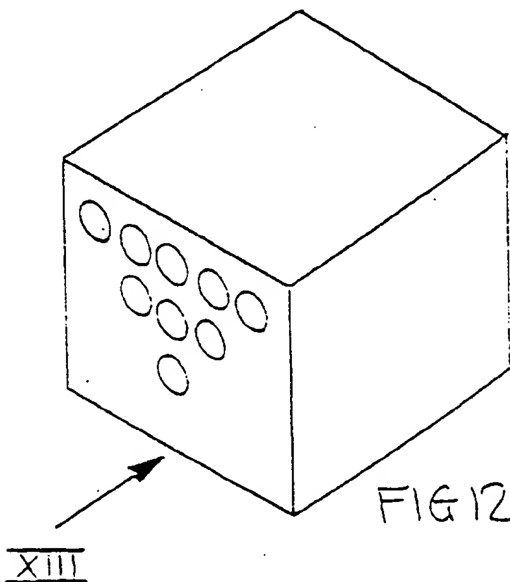

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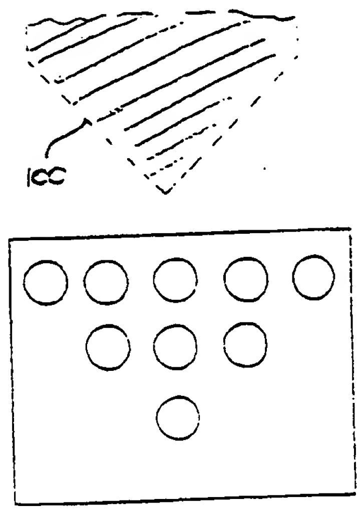


FIG 13

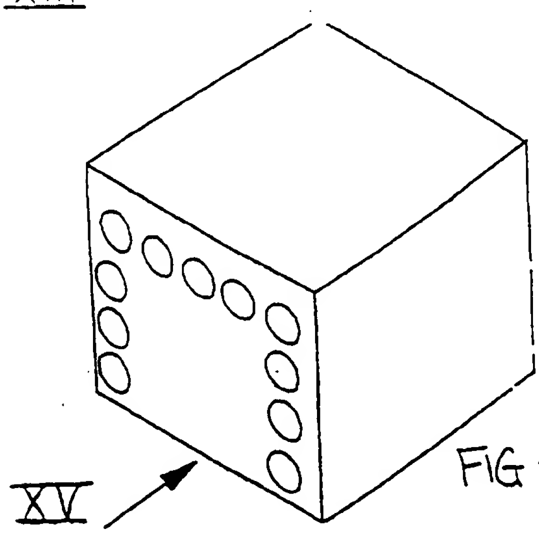


FIG 14

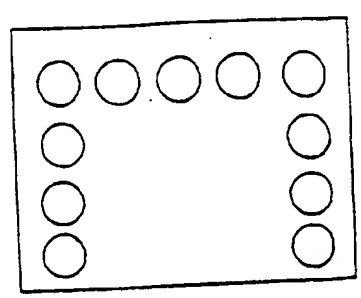


FIG 15

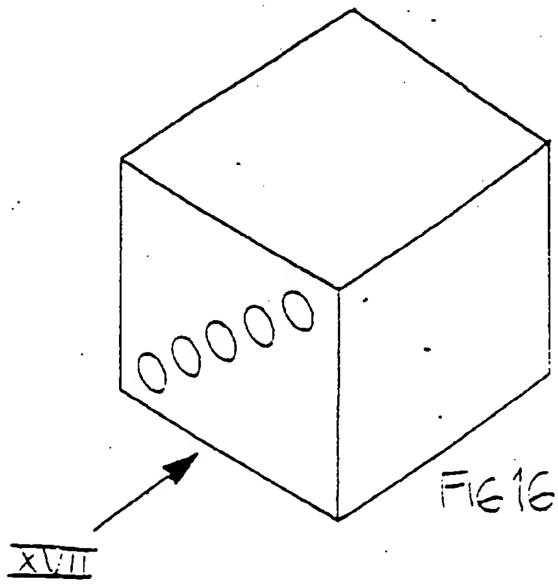


FIG 16

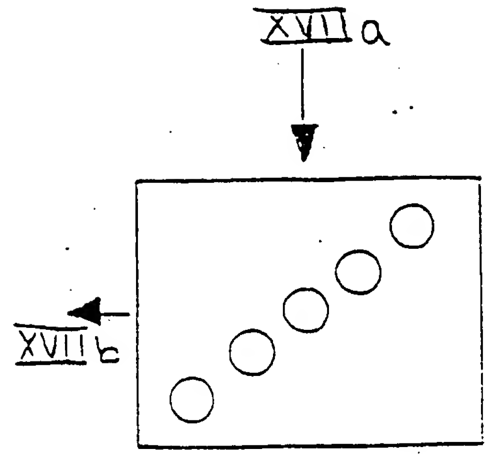
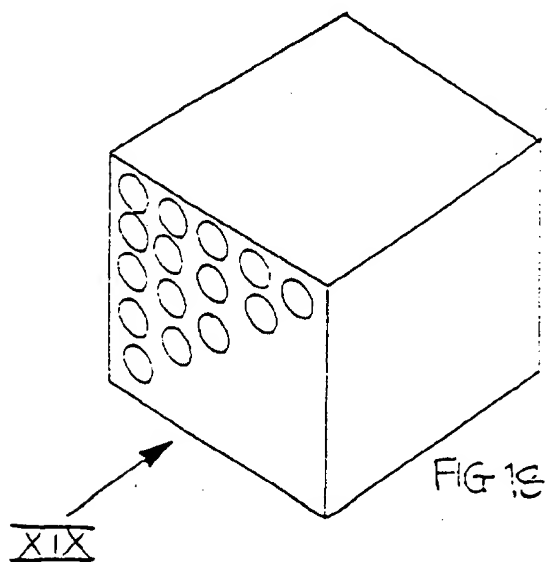


FIG 17



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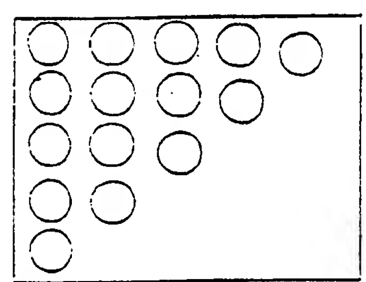

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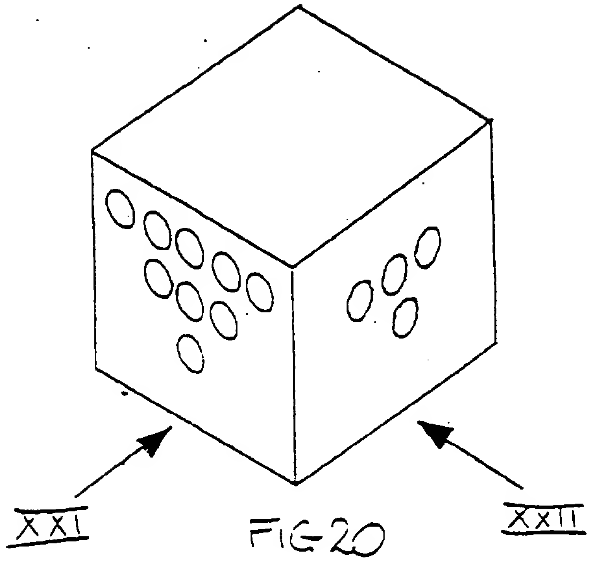

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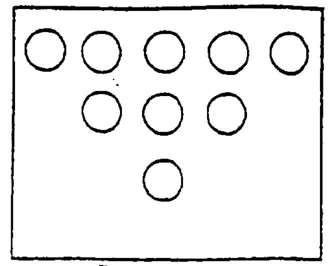

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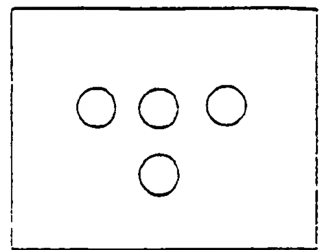

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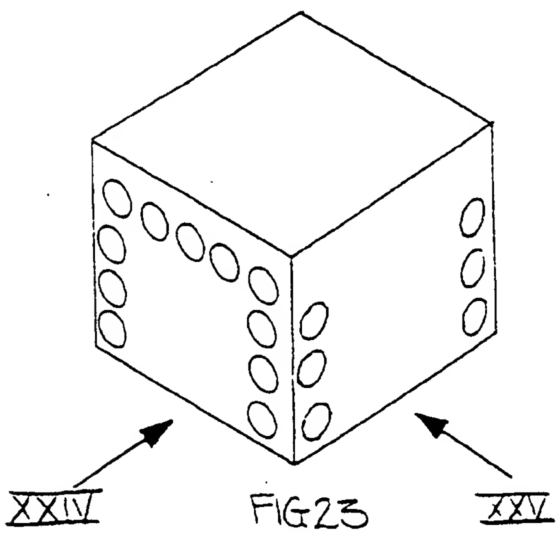


FIG 23

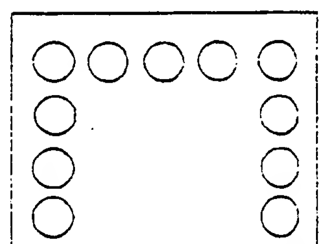


FIG 24

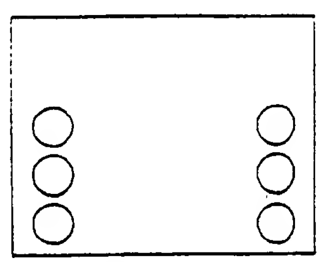


FIG 25

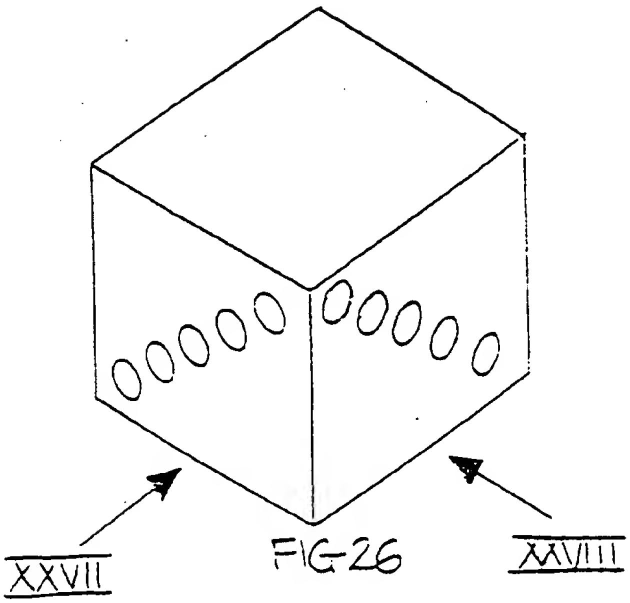
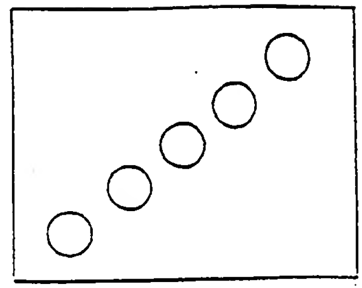


FIG 26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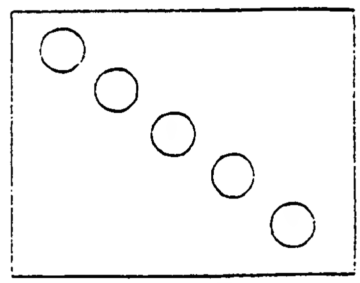
FIG 28

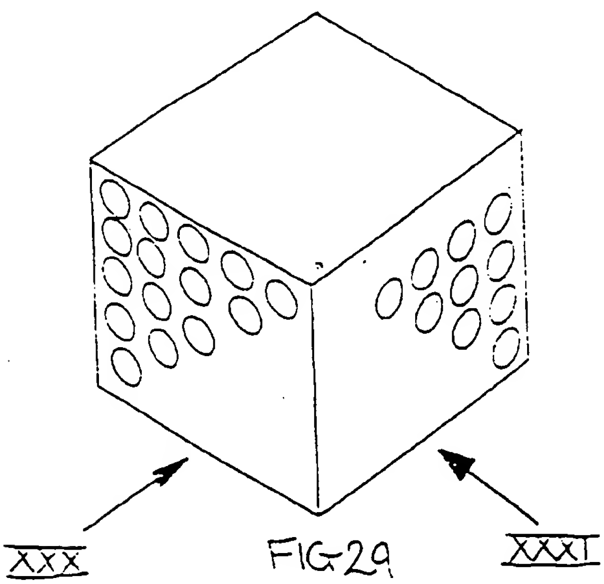

FIG 29

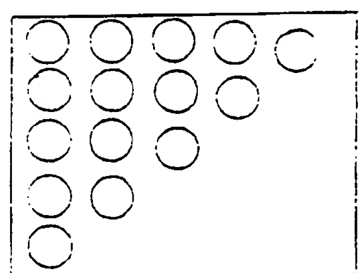
FIG 30

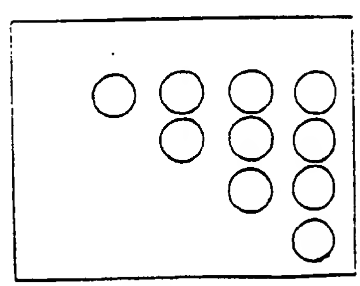
FIG 31

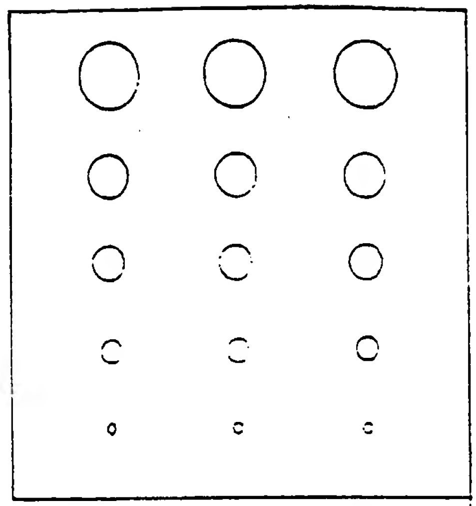

FIG32

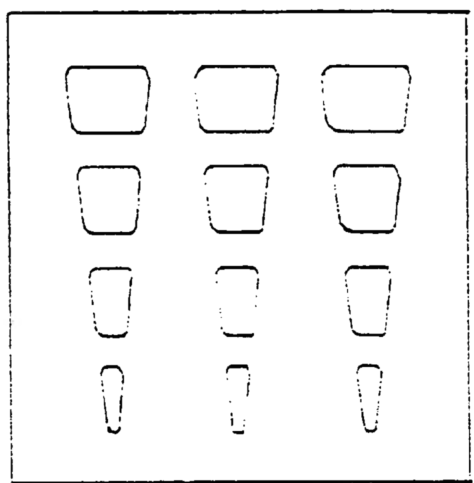

FIG33

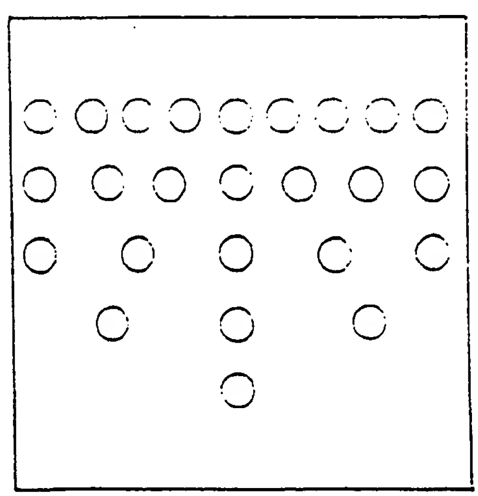

FIG34

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IMPACT ENERGY ABSORBER

This invention relates to an impact energy absorber for use in absorbing kinetic energy during impact caused by collisions. Impact energy absorbers have widespread use in many applications for reducing the potential for damage caused by damaged or malfunctioning equipment. They are also used on vehicles and barriers in order to mitigate traffic accidents or the like.

A suitable impact energy absorber may be constructed from a honeycomb or in the form of a foam. The structure of the absorber enables the absorber to accommodate large plastic deformations occurring when the absorber is subjected to a stress above a particular threshold. Those plastic deformations absorb kinetic energy, thereby providing the mechanism for absorbing impact energy.

A standard block of honeycomb structure has the property of crushing steadily under a precisely defined load. Accordingly, a steady deceleration rate may be obtained. However, in certain applications, a steady deceleration rate is not required and may in fact be disadvantageous. In some circumstances it may be preferable to produce a progressively increasing rate of deceleration by an impact energy absorber. For instance, in order to minimise injury to a pedestrian in collision with a vehicle fitted with an impact energy absorber, the impact energy absorber should be relatively readily collapsible in order that the collision decelerates at a low rate. In contrast, in

an impact between two vehicles fitted with impact energy absorbers, a higher deceleration rate is required in order to maximise energy absorption thereby protecting the occupants of the vehicle and therefore the impact energy absorbers are less readily collapsible than before.

It is an object of the invention to provide an impact energy absorber adaptable to predetermined rates of collapse and to variable rates of collapse appropriate to an application.

According to the invention there is provided an impact energy absorber comprising a plastically deformable body, the body comprising at least one local void. In that way, the void may be positioned suitably to produce desired variations in the strength of the impact energy absorber both in the direction of expected impact, and laterally thereof.

The void may be placed in the body so that the absorber exhibits collapse characteristics suitable for a given application.

The void may extend laterally across the absorber. In that way, the void produces variations in the strength of the impact energy absorber in the direction of expected impact, and does not vary the strength in the direction lateral to the expected impact direction.

Preferably, the body comprises a plurality of voids, the voids being positioned so that stress applied to the absorber in use causes successive plastic collapse of said voids prior to bulk plastic collapse of the body.

In that way, successive varying rates of plastic collapse may be selected for particular applications. For instance, a car bumper may be provided with voids such that a first collapse zone provides a low deceleration rate, followed by a second collapse zone providing a high deceleration rate.

The body may be of a honeycomb structure. In one embodiment, the honeycomb structure comprises a plurality of corrugated sheets attached together. The void or voids may be formed in one or more of the corrugated sheets before attachment together. Voids may be provided in each corrugated sheet. The voids may be aligned to form a lateral tubular void through the bulk of the body. In other forms, the body comprises an arrangement of tubes attached together.

The absorber according to the invention may be used in computer aided modelling of vehicles under test, the absorber being selected and voids positioned to mimic the known physical properties of the vehicle. Such an application is useful in destructive testing where the destruction of real body shells or chassis would be extremely

Other novel features of the invention will be recognised from the various preferred embodiments described hereinafter with reference to the accompanying drawings, in which:

Figure 1 shows a perspective view of an impact energy absorber not forming part of the present invention.

Figure 2 shows a view of the impact energy absorber of Figure 1 in the direction indicated by arrow II in Figure 1.

Figure 3 shows a perspective view of another impact energy absorber not forming part of the present invention.

Figure 4 shows a view of the modified prior art impact energy absorber of Figure 3 in the direction indicated by arrow IV.

Figure 5 shows a perspective view of a first impact energy absorber according to the invention.

Figure 6 shows a view of the impact energy absorber in Figure 5 in the direction indicated by arrow VI.

Figure 7 shows an ideal load v displacement graph for a compression test on the absorber of Figure 1 and 2.

Figure 8 shows an ideal load v displacement graph for a compression test on the absorber of Figures 3 and 4.

Figure 9 shows an ideal load v displacement graph for a compression test on absorber of Figures 5 and 6.

Figure 10 shows a perspective view of a second impact energy absorber according to the invention.

Figure 11 shows a view of the impact energy absorber in Figure 10 in direction by arrow XI.

Figure 12 shows a perspective view of a third impact energy absorber according to the invention.

Figure 13 shows a view of the impact energy absorber in Figure 12 in the direction indicated by arrow XIII, and under test.

Figure 14 shows a perspective view of a fourth impact energy absorber according to the invention.

Figure 15 shows a view of the impact energy absorber in Figure 14 in the direction indicated by arrow XV.

Figure 16 shows a perspective view of a fifth impact energy absorber according to the invention.

Figure 17 shows a view of the impact energy absorber in the direction indicated by arrow XVII.

Figure 18 shows a perspective view of a sixth impact energy absorber according to the invention.

Figure 19 shows the impact energy absorber of Figure 18 in the direction indicated by arrow XIX.

Figure 20 shows a perspective view of a seventh impact energy absorber according to the invention.

Figure 21 shows the impact energy absorber of Figure 20 in the direction indicated by arrow XXI.

Figure 22 shows the impact energy absorber of Figure 20 in the direction indicated by arrow XXII.

Figure 23 shows a perspective view of an eighth impact energy absorber according to the invention.

Figure 24 shows the impact energy absorber of Figure 23 in the direction indicated by arrow XXIV.

Figure 25 shows the impact energy absorber of Figure 23 in the direction indicated by arrow XXV.

Figure 26 shows a perspective view of a ninth impact energy absorber according to the invention.

Figure 27 shows the impact energy absorber of Figure 26 in the direction indicated by arrow XXVII.

Figure 28 shows the impact energy absorber in the direction indicated by arrow XXVIII.

Figure 29 shows a perspective view of a tenth impact energy absorber according to the invention.

Figure 30 shows the impact energy absorber of Figure 29 in the direction indicated by arrow XXX.

Figure 31 shows the impact energy absorber of the Figure 29 in the direction indicated by arrow XXXI.

Figure 32 shows a first pattern of voids for use with the invention.

Figure 33 shows a second pattern of voids for use with the invention.

Figure 34 shows a third pattern of voids for use with the invention.

Referring firstly to Figures 1 and 2, a prior art impact energy absorber 10 is constructed of stainless steel honeycomb section material, and is formed in a cuboid shape with the axis of the honeycomb cells parallel to one axis of the cuboid. The

honeycomb is constructed by means of welding corrugated stainless steel plate according to established procedures.

Figure 7 illustrates the graph of the relative displacement of the end faces 1 and 2 of the absorber 10 against a compressive load applied there between. It can be seen that initially load increases rapidly for a small displacement. Thereafter, load remains substantially constant through a relatively large displacement while buckling of side walls of the honeycombs structure takes place. After buckling is completed, load must increase to produce further displacement.

Figures 3 and 4 of the drawings show another exemplary impact energy absorber 20, one end of which has snubbed edges.

Figure 8 shows a graph of load against displacement for absorber 20. It can be seen that the initial slope of the graph is lower that of the graph in Figure 7 and so the initial deceleration provided by the impact energy absorber is lower than that of Figures 1 and 2.

Figures 5 and 6 show an impact energy absorber 30 constituting a first specific embodiment of the invention. The absorber 30 is generally of the same construction as that of Figures 1 and 2 in that it is generally cuboid and of a honeycomb section.

Honeycomb section is constructed from individual corrugated sheets. Circular apertures 32 are pressed through the individual corrugated sheets. The apertures 32 are arranged in rows parallel to the end faces of the absrober. Within rows, the apertures have substantially identical diameters. The diameters of the apertures 32 decrease from one end face to the other. On assembling the absorber constructed of corrugated sheets having the apertures 32, voids can be produced in the absorber 30.

Figure 9 shows a load displacement graph for the absorber 30 of Figures 5 and 6. Initially, load causes a controlled incremental collapse of the voids created by the apertures 32, starting with larger voids and ending with smallest. Then the absorber behaves in a similar fashion to those previously described. Accordingly, a controlled collapse of the absorber 30 can be obtained, with an initially low collapse load causing an initially low deceleration rate, increasing to a higher collapse load and a higher deceleration rate.

Different arrangements of voids within the absorber will produce different load displacement graphs according to different needs.

For instance , in Figures 10 and 11, the absorber has a row of parallel cylindrical voids adjacent one end face in order to remove any initial peak load which might be required to initiate buckling and crushing of the absorber.

The absorber of Figure 12 and Figure 13 is provided with voids along one end face and therein into the centre of the absorber in order to absorb a particular shape impacting object 100.

Figures 14 and 15 show a fourth impact energy absorber having voids along one end face and two side faces in order to weaken the periphery of the absorber. That arrangement would be particularly useful in the case of impact with a pedestrian whereby deceleration experienced by the pedestrian is reduced.

Figures 16 and 17 show a fifth impact energy absorber having a row of voids extending through the body of the absorber, the row being diagonal of the end faces and side faces.

Figures 18 and 19 show a sixth impact energy absorber similar to the fifth impact energy absorber of Figure 16 and Figure 17 but with further voids through the body to one side of the diagonal row. In each of those cases, an object colliding with the impact energy absorber in the direction given at XVIIa in Figure 17 will tend to deflect into the direction given by the arrow at XVIIb of Figure 17. In particular, the impact energy absorber illustrated in Figures 18 and 19 has one side weaker than the other.

Figures 20, 21 and 22 show a seventh impact energy absorber similar to the third

impact energy absorber shown in Figure 12 but wherein the voids extend in two perpendicular directions and parallel to the end faces.

Figures 23, 24 and 25 show an eighth impact energy absorber similar to the fourth impact energy absorber of Figure 14 but having a similar arrangement of voids extending in two perpendicular directions parallel to the end face. Such an arrangement may further selectively weaken the peripheral faces of the impact energy absorber.

Similarly, Figures 26, 27 and 28 and Figures 29, 30 and 31 correspond to the arrangements shown in Figures 16 and 18 respectively. The structure may be thereby selectively weakened to a greater extent.

Figures 32, 33 and 34 show three different arrangements of apertures on a corrugated sheet. Figure 32 shows an arrangement substantially as is used in the absorber illustrated in Figures 5 and 6, whereas Figure 33 has generally trapezoidal apertures of diminishing area from one edge, and Figure 34 shows a distribution of identical circular apertures concentrated at one edge of the corrugated sheet and becoming more dispersed towards the opposite edge. These arrangements will produce a different load displacement characteristic suitable for particular applications.

CLAIMS

1. An impact energy absorber comprising a plastically deformable body, the body including at least one void.

2. An impact energy absorber as defined in claim 1 in which the or each void alters the energy needed to deform the body in the locality of the void.

3. An impact energy absorber as defined in claims 1 or 2 in which the or each void is positioned such that the body is adapted to a pre-determined rate of collapse in a pre-determined direction of collapse.

4. An impact energy absorber as defined in any preceding claim in which the void is orientated laterally to a pre-determined direction of collapse.

5. An impact energy absorber as defined in claim 4 in which the void extends through the body.

6. An impact energy absorber as defined in any preceding claim with a plurality of voids which provide for two collapse zoncs of the body which requirement different forces to collapse each zone.

7. An impact energy absorber as defined in any preceding claim in which there is a plurality of sets of voids, one set being positioned at a different axial location relative to another set with regard to a pre-determined direction of collapse of the body.

8. An impact energy absorber as defined in any preceding claim including a plurality of sets of voids, one set of voids having different sized voids to another set of voids.

9. An impact energy absorber as defined in any preceding claim including a plurality of sets of voids, one set of voids having a different orientation relative to another set of voids.

10. An impact energy absorber as defined in any preceding claim including a plurality of sets of voids one set of voids having a different number of voids relative to another set of voids.

11. An impact energy absorber as defined in any preceding claim having a plurality of sets of voids, the shape of the voids of one set being different from the shape of the voids of another set.

12. An impact energy absorber as defined in any preceding claim in which the or each void is positioned such that the void produces a variation in the strength of the impact energy absorber in a pre-determined direction of collapse, but does not significantly vary the strength of the impact energy absorber in a direction lateral to the pre-determined direction of collapse.

13. An impact energy absorber as defined any preceding claim in which the or each void is positioned so as to provide a weaker side of the body and a stronger side of the body with regard to a pre-determined direction of collapse.

14. An impact energy absorber as defined in any preceding claim in which the or each void is positioned so as to provide one or more weaker peripheral faces of the body.

15. An impact energy absorber as defined in any preceding claim in which the or each void is positioned so as to mimic known physical properties of another structure.

16. An impact energy absorber as defined in any preceding claim in which the body comprises a honey-comb structure.

17. An impact energy absorber as defined in any preceding claim 16 in which the honey-comb comprises a plurality of corrugated sheets.

18. An impact energy absorber as defined in claim 17 in which the or each void is formed by assembly of a plurality of pre-pierced corrugated sheets.

19. An impact energy absorber as herein before described with reference to or as shown in figures 5 and 6, or 10 and 11, or 12 and 13, or 14 and 15, or 16 and 17, or 18 and 19, or 20, 21 and 22, or 23, 24 and 25, or 26, 27 and 28, or 29, 30 and 31, or 32, or 33, or 34 of the accompanying drawings.

The Patent Office

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Application No:	GB 9805462.0	**Examiner:**	Colin Thompson
Claims searched:	1 to 19	**Date of search:**	9 July 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): F2F (SCM)

Int Cl (Ed.6): F16F 7/12

Other: Online: WPI, EDOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,P	GB 2305487 A	(Darchem Eng Ltd) See Figs 3-6	1-6,14,16, 17
X	GB 2083162 A	(Energy Absorption Systems Inc) See Figs 4 & 5	1,4--10,16, 17
X	GB 2003254 A	(Porsche AG) Whole document relevant	1-8
X	GB 1588328 A	(H H Robertson Co) Whole document relevant	1-3,5,6,8, 11,16,17
X	GB 1582606 A	(Mitsubishi Jidosha KKK) Whole document relevant	1-9
X	WO 95/25646 A1	(Besin BV) Whole document relevant	1-6,8,10, 16,17

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
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